# Guest Editorial
# Recent Advances in Autonomic Communications

Today's networks must cope with a wide diversity of traffic, services, and external threats. The response to these requirements has been a growing sophistication of network elements and their interactions. Examples include: services running on top of virtual networks, increased computational sophistication of network elements (e.g., for intrusion detection), and complex adaptation mechanisms in network protocols across all layers of the stack.

Autonomic communications strive to ease the burden of managing complex and dynamic networks, especially to increase robustness, scalability, and facilitate the addition of new services. By autonomic, we mean self-managing capabilities such as self-configuring, self-healing, self-optimizing, and self-protecting. Self-configuring networks provide low cost management and facilitate adaptation to traffic and new services. Self-healing networks reduce the burden of managing failures. Self-optimizing networks make efficient use of the underlying components and enhance scalability. Self-protecting networks are robust to denial of service attacks and other external threats.

This special issue presents recent results in the area of autonomic communications. A total of forty papers were submitted for this special issue. After extensive review and discussion, nine papers were selected for publication.

This issue addresses four areas in which autonomics play a central role: network architectures, traffic management, monitoring, and resource management. Architecture defines the network elements, and hence their autonomic capabilities. Traffic flows between network elements, and so the management of these flows demands capabilities for self-healing and self-optimization. The combination of network architecture, traffic flows, and monitoring are impacted by and establish requirements for the autonomics of resource monitoring and management.

Two papers in the special issue address network architectures. In "The Autonomic Network Architecture (ANA)," Bouabene et al. propose a set of abstractions for defining self-managing networks. For example, the authors define a compartment (which use the same conventions for naming and addressing), and information channels, which provide access to the services provided by compartments. The authors show how these abstractions can be used to build address-agnostic applications and network registries.

In "MMS: An Autonomic Network-Layer Foundation for Network Management," Gogineni et al. address a common weakness in network management—management plane communications. The authors propose improvements to the robustness of management plane communications that integrates self-configuration through the creation of management channels, self-protection (especially against denial-of-service attacks), and a combination of self-healing and self-protection through liveness checking of communication paths.

The special issue contains three articles that address traffic and routing. In "Enabling Routing Control in a DHT," Zhang et al. observe that distributed hash tables (DHTs) have characteristics that facilitate many self-managing properties for routing, especially scalability and self-organization. However, a straight-forward use of DHTs assumes homogeneous characteristics of communication participants, an assumption that is contrary to techniques such as destination-specified routing and path-constrained routing. The contribution of this paper is to show how DHTs can be applied when participant nodes are not homogeneous.

In "Autonomic Traffic Engineering for Network Robustness," Tizghadam et al. describe a framework for traffic engineering for autonomic networks. The ability of a network to meet service level agreements (SLAs) is determined by capabilities of the network elements, the pattern of routing requests between network elements, and the source-destination requirements of external requests to the network. Uncertainties in any of these characteristics can lead to sub-optimal provisioning strategies. The authors propose an approach called AutoNet that uses feedback to cope with dynamics to optimize traffic engineering.

In "Two Phase Load Balanced Routing using OSPF," Antic et al. describe an intra-domain routing protocol that improves on shortest path approaches by using load balancing. The protocol, LB-SPR, has been implemented in the TPC/IP stack, and the authors demonstrate improvements using simulation studies.

Two papers in this issue address monitoring, an essential part of any self-managing system. In "Event Detection and Correlation for Network Environments," Sifalakis et al. discuss the detection and classification of patterns (e.g., for alerting or automated response) in network data from which network state is distilled. This is non-trivial in that simple Boolean logic is not sufficient to define the necessary patterns, and there is some complexity with distinguishing anomalous state from the effects of automated actions taken by the management plane.

In "On Cost-Aware Monitoring for Self-Adaptive Load Sharing," Breitgand et al. address a key trade-off in self-managing networks: between the value of the information obtained from monitoring and the load that monitoring imposes. An analytical approach is used in which service requests compete with monitoring requests. The authors formulate self-adaptive policies for both centralized and distributed environments.

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Inherent in self-managing networks is the need to take action, typically through resource management. In "Scalable Service Migration in Autonomic Network Environments," Oikonomou et al. address the migration of services between nodes using local information about communication costs. Three policies are considered. The first ensures that movement always results in declining costs, although it does not necessarily minimize cost. A second policy makes use of tentative moves to achieve optimal costs, although doing so introduces new costs. The third policy considers both communication costs and the cost of tentative moves.

In "Double Auction Mechanism for Resource Allocation in Autonomous Networks," Iosifidis et al. make use of market-based mechanisms for resource allocation. A market-based mechanism is a natural representation for many networking problems. For example, managing the life of batteries in ad hoc wireless networks can be viewed as a market problem in which network nodes make decisions about spending scarce battery power, either to send their own messages or forward messages from other nodes. Clearly, both expenditures are required for the network to function. The authors propose a light-weight feedback mechanism and pricing strategies to induce desirable node behavior.

We express our thanks to the authors who submitted papers and to the reviewers for their thoughtful comments. It has been a pleasure to put together an issue on an area that is both timely and holds much promise for practical impact.

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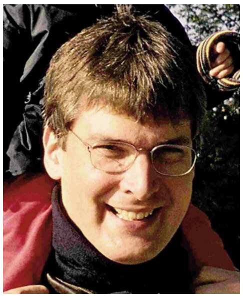

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